THE WEATHER AND CIRCULATION OF NOVEMBER 1959

Unusually High Persistence From October

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1. HIGHLIGHTS

The outstanding feature of November 1959 was the marked persistence of both circulation and weather from October 1959. Subnormal temperatures continued to dominate most of the United States,[1] with a period near mid-month of unusual cold from the Middle and Upper Mississippi Valley to the Pacific Northwest. The coldest weather was centered in Montana, where long-period temperature and precipitation records were broken. The cold wave was quickly followed by rapid warming and a circulation reversal which heralded a change in regime during the latter part of the month. Other highlights of November were the continued lack of rainfall in much of California and Nevada, record snowfall in Montana, and heavy rains in southern Florida.

2. PERSISTENCE FROM OCTOBER

The circulation pattern at 700 mb., over the Pacific and North America was extremely persistent from October to November 1959. This is apparent from a comparison of the 700-mb. mean contours and anomaly patterns for November (figs. 1 and 2) with those for October (figs. 1 and 2 of [1]). Over a grid extending from 30° to 50° N. and from 70° to 130° W., the lag correlation between the October and November patterns of height anomaly was +0.87. This is considerably higher than the 1933–59 average (–0.02) and the highest ever observed for this 27-year period.

The temperature and precipitation patterns over the United States were also highly persistent from October to November 1959. In table 1 are shown the class changes of monthly mean temperature and total precipitation for an array of 100 fairly evenly distributed stations. With respect to temperature, the classes much above and much below normally occur 12½ percent of the time each, and above, normal, and below normally occur 25 percent of the time each. Persistence of temperature may be considered in terms of the total zero-plus-one class change [2]. From October to November 1959, 85 percent of the country did not change by more than one class. This is well above the average of 61 percent for the period 1942–1959.

TABLE 1.—*Class changes of weather anomalies in the United States from October to November 1959*

Temperature		Precipitation	
Class change	Frequency (%)	Class change	Frequency (%)
0	33	0	46
1	52	1	38
2	14	2	16
3	1		
4	0		

Precipitation is divided into three classes, each normally occurring 33⅓ percent of the time, and persistence generally refers to zero class changes only [2]. From table 1, it is seen that 46 percent of the country remained in the same precipitation class from October to November 1959. This is the second highest precipitation persistence observed during the period 1942–59 and well above the average of 34 percent for the same period.

3. MONTHLY MEAN CIRCULATION

The average circulation pattern at 700 mb. for November 1959 (fig. 1) was of a relatively simple sinusoidal type with well defined trough-ridge systems close to their normal positions [3]. This circulation was remarkably similar to October's circulation, not only over North America as mentioned in the previous section, but also over eastern Asia and the Pacific. This is evident from the small anomalous height changes between the two months (fig. 2). The greatest change in circulation occurred over Russia, where 700-mb. heights rose as much as 610 feet as a deep trough at middle and high latitudes was replaced by a strong ridge. A change of lesser magnitude in the Atlantic was associated with replacement of rather flat cyclonic flow by a slightly stronger than normal ridge (fig. 1).

Blocking during November was centered primarily in higher latitudes where 700-mb. heights were above normal

[1] United States as used in this paper does not include Alaska and Hawaii

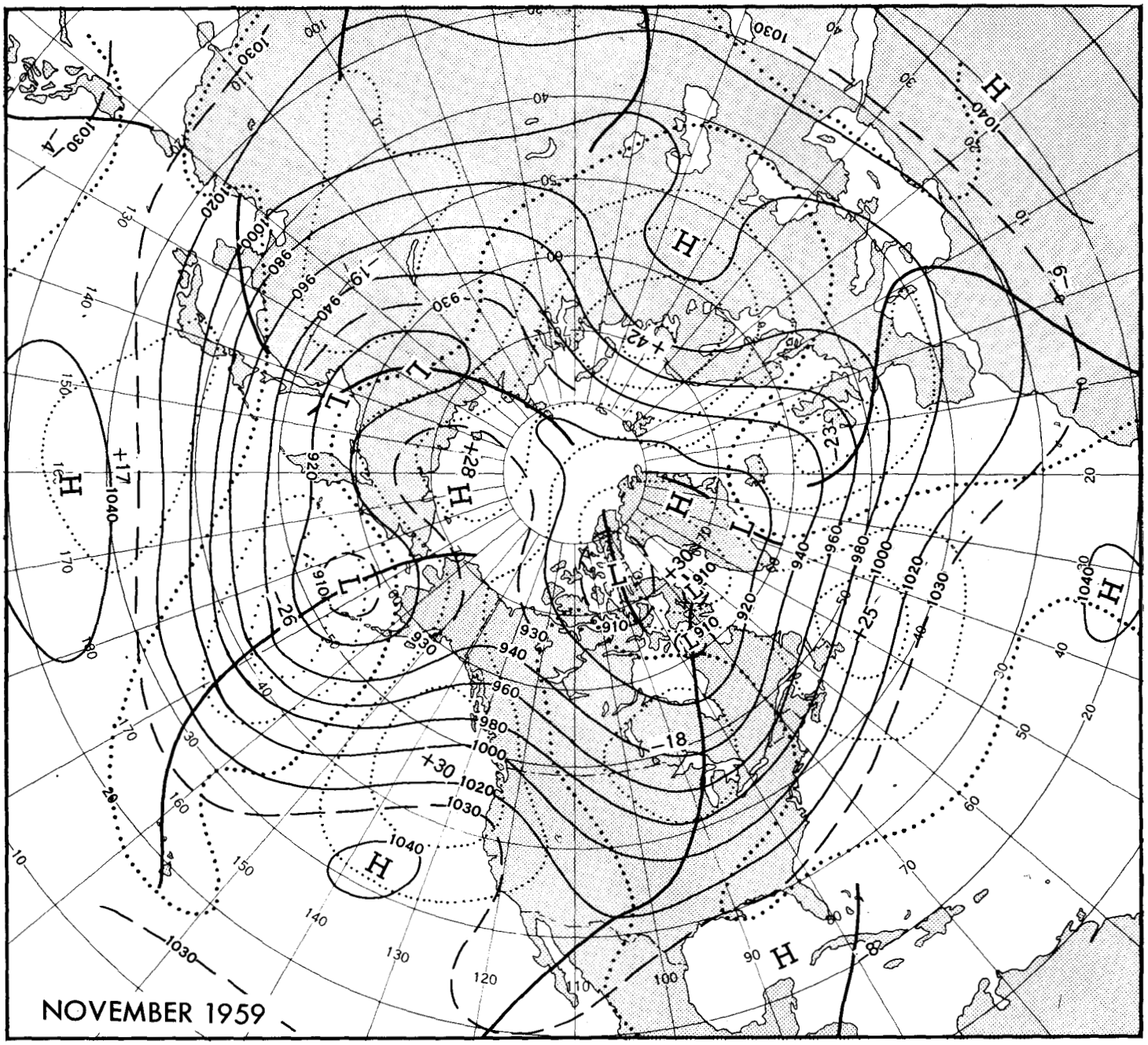

FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for November 1959. Principal features affecting United States weather were the strong ridge along the west coast of North America and the deep trough in mid-continent.

north of 70° N. (fig. 1). The strong blocking High centered over the Bering Sea and Kamchatka Peninsula during October [1] weakened as it moved northwestward, and in November it was centered over the Arctic basin. Relaxation of this block allowed the Aleutian Low to deepen and move northward from its October position. Weak blocking appeared in North America in the form of an area of positive height anomaly centered over Davis Strait. The strongest blocking affected Europe and Russia and was associated with an extensive area of positive height anomaly centered over the Barents Sea (fig. 1).

The principal axis of maximum west wind at 700 mb. appeared as a well defined jet extending around nearly the entire Northern Hemisphere (fig. 3). Over Europe this jet separated into two branches in association with the block affecting that region. The southern branch was related to a storm track located farther south than usual and with consequent increased storminess in the Mediter-

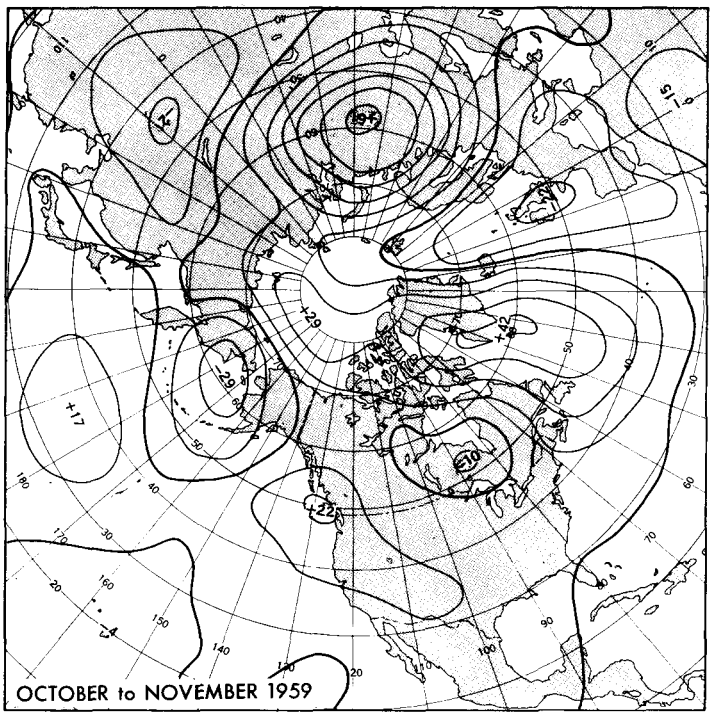

FIGURE 2.—Change in monthly mean 700-mb. height anomalies (tens of feet) from October to November 1959. Small changes in North America and the Pacific reflect great persistence of the circulation.

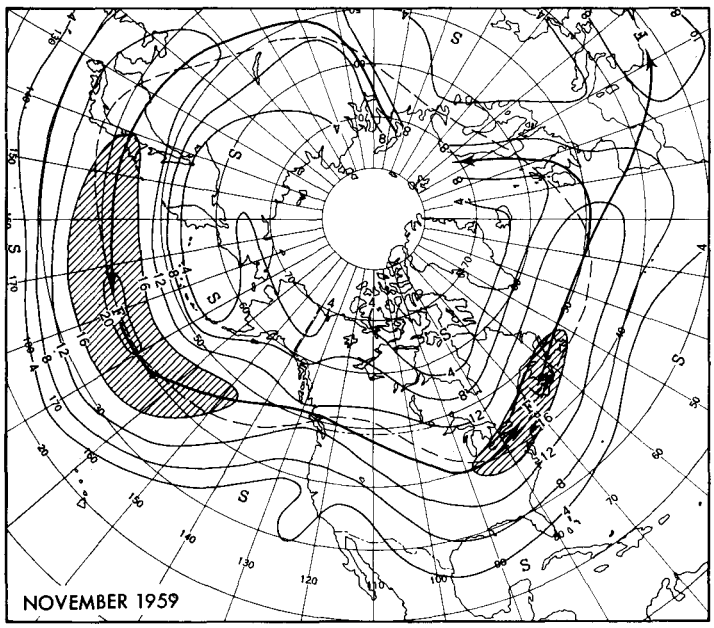

FIGURE 3.—Mean 700-mb. isotachs (meters per second) for November 1959. Solid arrows indicate position of the principal jet axis, which was close to its normal position (dashed) over the entire Northern Hemisphere. "F" and "S" show centers of fast and slow wind speeds respectively. Areas of wind speed greater than 16 m.p.s. are hatched.

ranean and southern Europe during November. Wind speeds in the primary jet were strongest over the mid-Pacific and New England but mostly subnormal over the southern portion of the Atlantic, most of Europe, and central Asia.

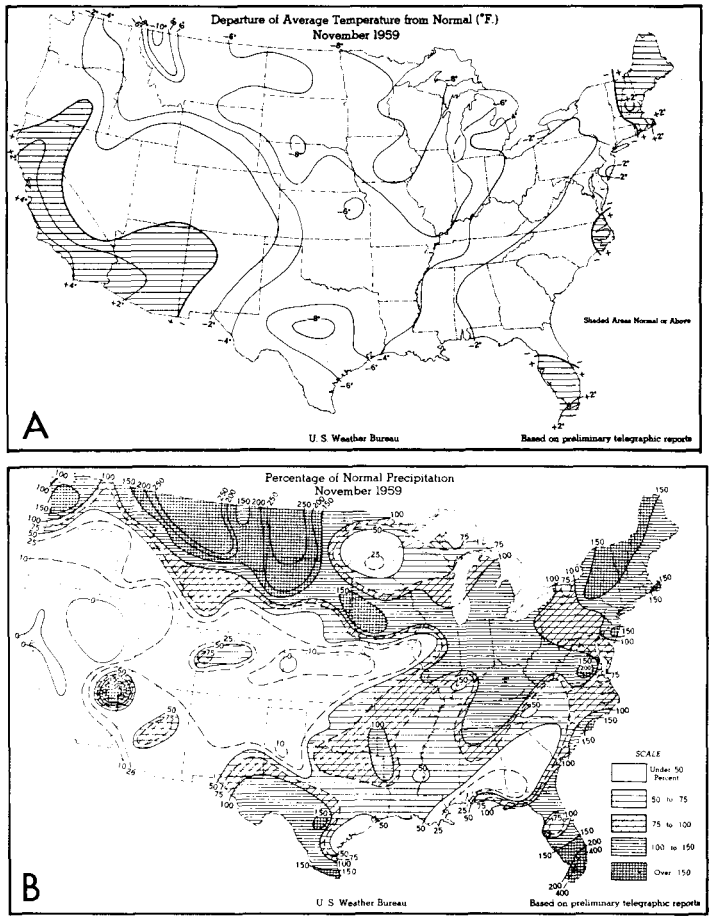

FIGURE 4.—(A) Departure of average surface temperature (°F.) from normal for November 1959, (B) Percentage of normal precipitation for November 1959. (From *Weekly Weather and Crop Bulletin, National Summary*, vol. XLVI, No. 49, December 1959.)

4. AVERAGE UNITED STATES WEATHER IN RELATION TO THE MEAN CIRCULATION

November 1959 was unusually cold over much of the Nation, with greatest temperature departures extending from the southern Plains to the Great Lakes and westward to the northern Rocky Mountain States (fig. 4A). In many areas from Texas to the western Great Lakes this was the coldest November of record. The greatest departure was observed at International Falls, Minn., where the average temperature for the month was 10°F. below normal. The most extreme cold was experienced in Montana and will be discussed in the following section. Temperatures of −22°F. at Valentine, Nebr. and −19°F. at Rapid City, S. Dak. on the 14th were record November minima, while at Sheridan, Wyo. it was −25°F. on the 16th, the second lowest temperature ever recorded in November. Many daily minimum temperature records, too numerous to mention, were established throughout the Nation. From Texas northeastward the coldest weather was generally experienced on the 17th and 18th, when many stations reported their lowest temperatures ever observed so early in

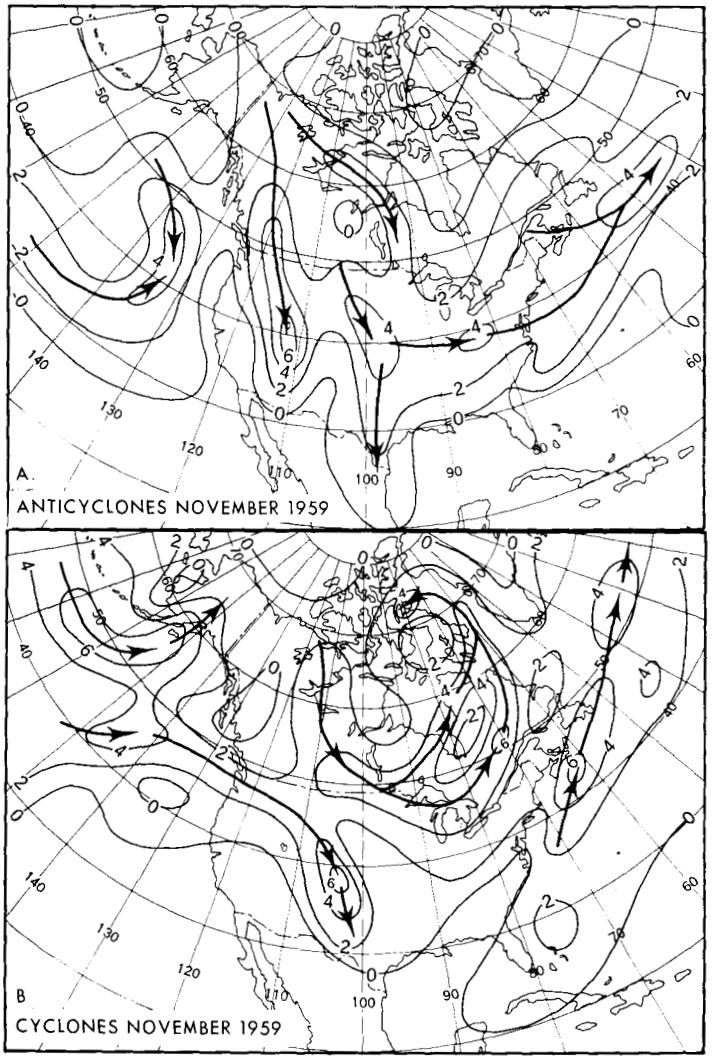

FIGURE 5.—Frequency of (A) anticyclone passages and (B) cyclone passages (within equal area boxes of 66,000 n. mi.²) during November 1959. Primary tracks are indicated by solid arrows.

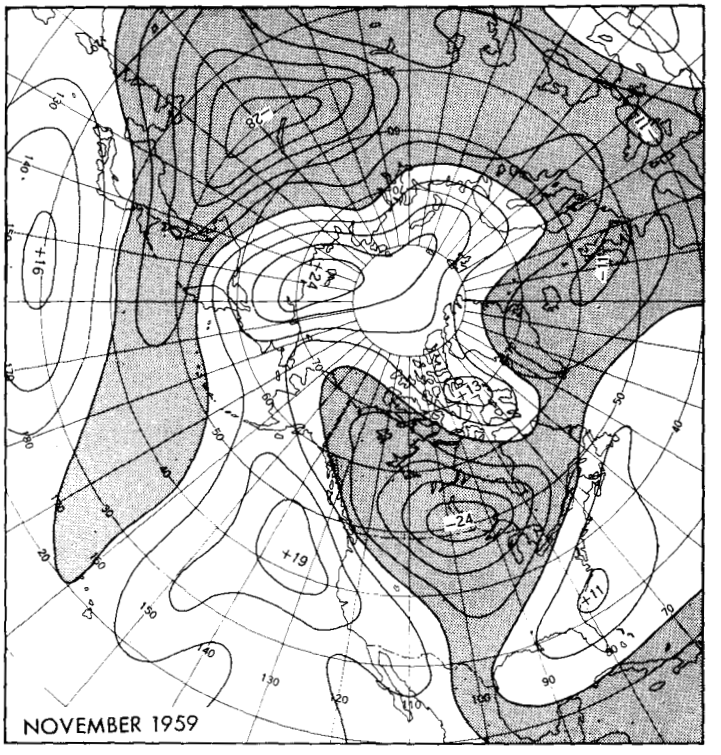

FIGURE 6.—Mean 1000–700-mb. thickness departure from normal (in tens of feet) for November 1959, with areas of subnormal values shaded. Abnormally cold air covered much of North America.

the season. This cold was associated with a strong Arctic high pressure area which brought a sea level pressure of 30.84 inches to Dallas, Tex., on the 17th, a new November record.

The unseasonable cold was associated with stronger than normal northerly flow between the strong ridge along the west coast of North America and the deep trough over the mid-continent (fig. 1). Sea level pressures averaged as much as 8 mb. above normal in British Columbia (see chart XI in [4]), while there were two primary anticyclone tracks associated with the cold polar outbreaks, one on either side of the Continental Divide (fig. 5A). Northwesterly flow aloft over the Rockies tended to contain the coldest weather east of the Divide (figs. 1, 4A). The mean monthly thickness of the layer between 1000 mb. and 700 mb. was also abnormally cold over much of North America, with greatest departures centered over Manitoba (fig. 6).

Most of California continued to observe above normal temperatures. This was the warmest November at San Diego during a period of record dating to 1872. Blue Canyon had its warmest November in 59 years of record. Bakersfield (83° F.) and Fresno (78° F.) reported record high temperatures for so late in the season on the 27th. At Los Angeles the average daily temperature was 1° F. below normal on the 4th, the first day the temperature had been below normal since February 22, 1959. The California warmth was related to the strong mean ridge along the coast (fig. 1). In addition easterly anomalous flow resulted in frequent Santa Ana winds.

November's precipitation pattern (fig. 4B) is not too difficult to relate to the mean circulation. In general, the heaviest amounts fell near or just to the north of the primary jet axis at 700 mb. (fig. 3). More than twice the normal amount of precipitation occurred in portions of Montana, the Dakotas, and Iowa (fig. 4B). Much of this was in the form of snow and resulted in record or near record depths for the month of November. Disturbances entering the Pacific Northwest and following a primary track southeastward along the Divide (fig. 5B) contributed most of this precipitation. A second storm track along the Canadian border produced lesser amounts in the Northern Plains States and Upper Mississippi Valley.

Much of the precipitation in the East was related to the deep trough in the central United States (fig. 1, 4B). The Northeast was generally wet and cloudy with less

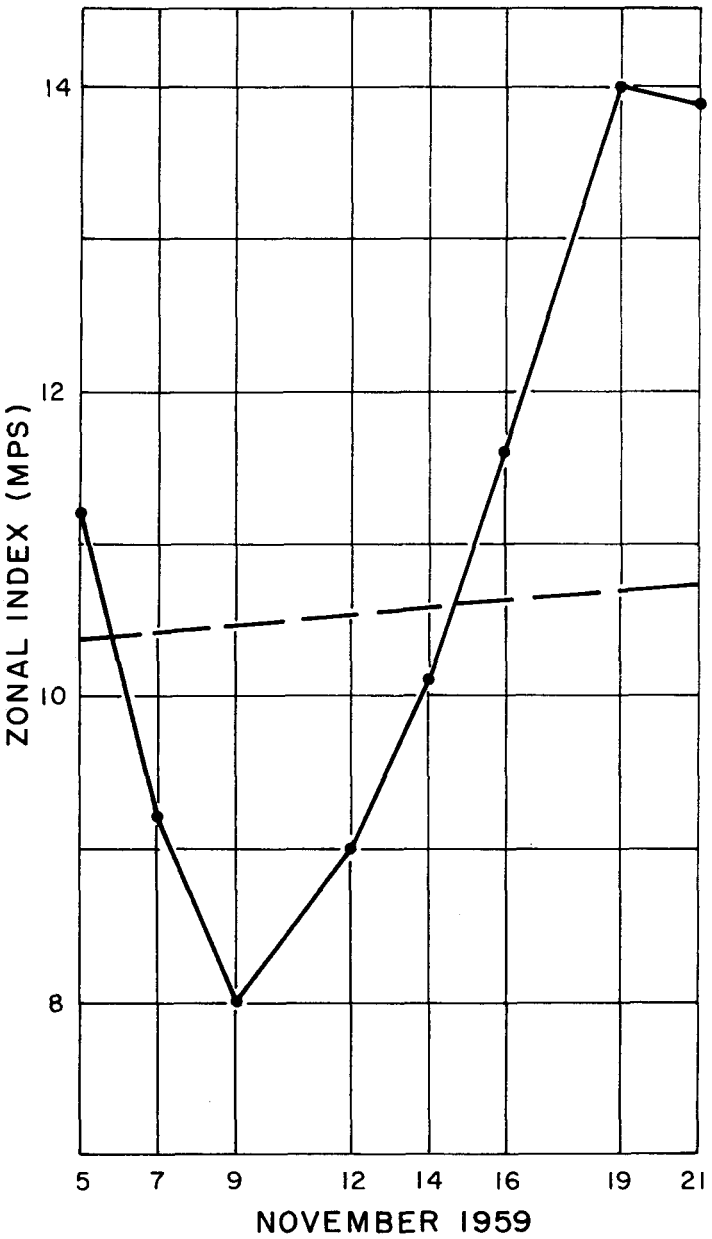

FIGURE 7.—Time variation of speed of 700-mb. westerlies averaged over North America and the Pacific between latitudes 35° and 55° N. and longitudes 65° W. and 175° E. Solid line connects 5-day mean zonal index values (plotted at middle of period and computed thrice weekly), while dashed line gives the corresponding normal. Severe weather changes accompanied the pronounced index cycle.

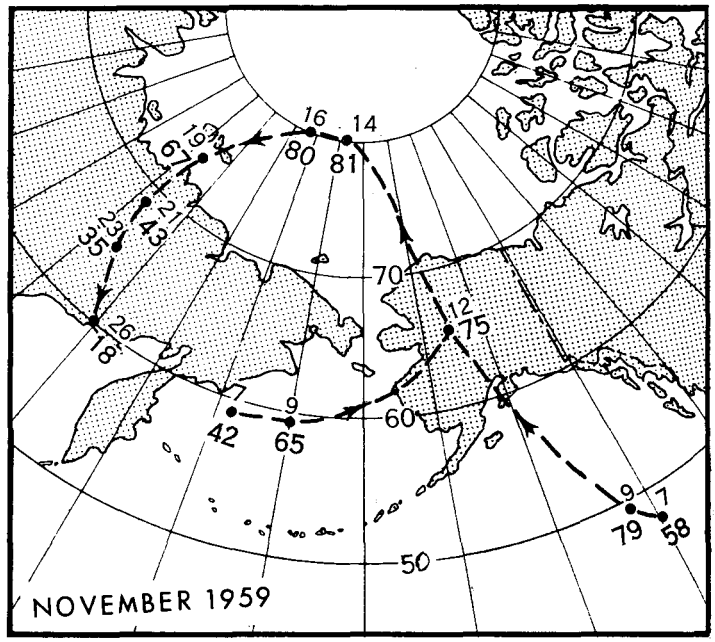

FIGURE 8.—Tracks of important 700-mb. 5-day mean positive anomaly centers during November 1959. Top number is middle day of period; lower number, intensity of center (tens of feet). Coalescence of anomaly centers accompanied pronounced amplification of the circulation pattern.

sunshine than normal as a result of stronger than normal southerly flow at sea level (chart XI in [4]) and aloft (fig. 1). In portions of the Southeast less than half the normal amount of precipitation fell during November (fig. 4B). This was related to the lack of cyclone passages (fig. 5B) and to the weak ridge of positive anomaly at 700 mb. (fig. 1). Rainfall in southern Florida was well above the normal, with Miami receiving 13.15 inches, a new November record. Of this, 7.93 inches fell during a 24-hour period, also a record for the month. This heavy precipitation was associated with an easterly wave and below normal heights at 700 mb. (fig. 1).

From the Central Plains States to the Pacific coast, precipitation was generally well below normal (fig. 4B). Many areas, principally in Nevada and California, reported no precipitation at all. This was the first November since 1929 without rain at San Francisco, Calif., and, at month's end, 73 consecutive days had passed without any measurable precipitation there. The moisture deficiency in the West was associated primarily with stronger than normal northerly anticyclonic circulation at 700 mb. (fig. 1).

5. INTRAMONTHLY VARIABILITY IN WEATHER AND CIRCULATION

An extreme change in weather and circulation associated with an index cycle (fig. 7) occurred near midmonth. This pronounced change apparently had its origin in the Pacific, where, during the first week of November, the mean circulation consisted of a trough in the middle flanked by ridges. The western ridge, which extended to the Kamchatka Peninsula, strengthened as it moved slowly eastward and developed a closed anticyclonic circulation at the 700-mb. level over the Bering Sea. At the same time the Aleutian Low was displaced well to the south and, as the pattern amplified, a strong cold air injection accompanied intense cyclogenesis at lower lati-

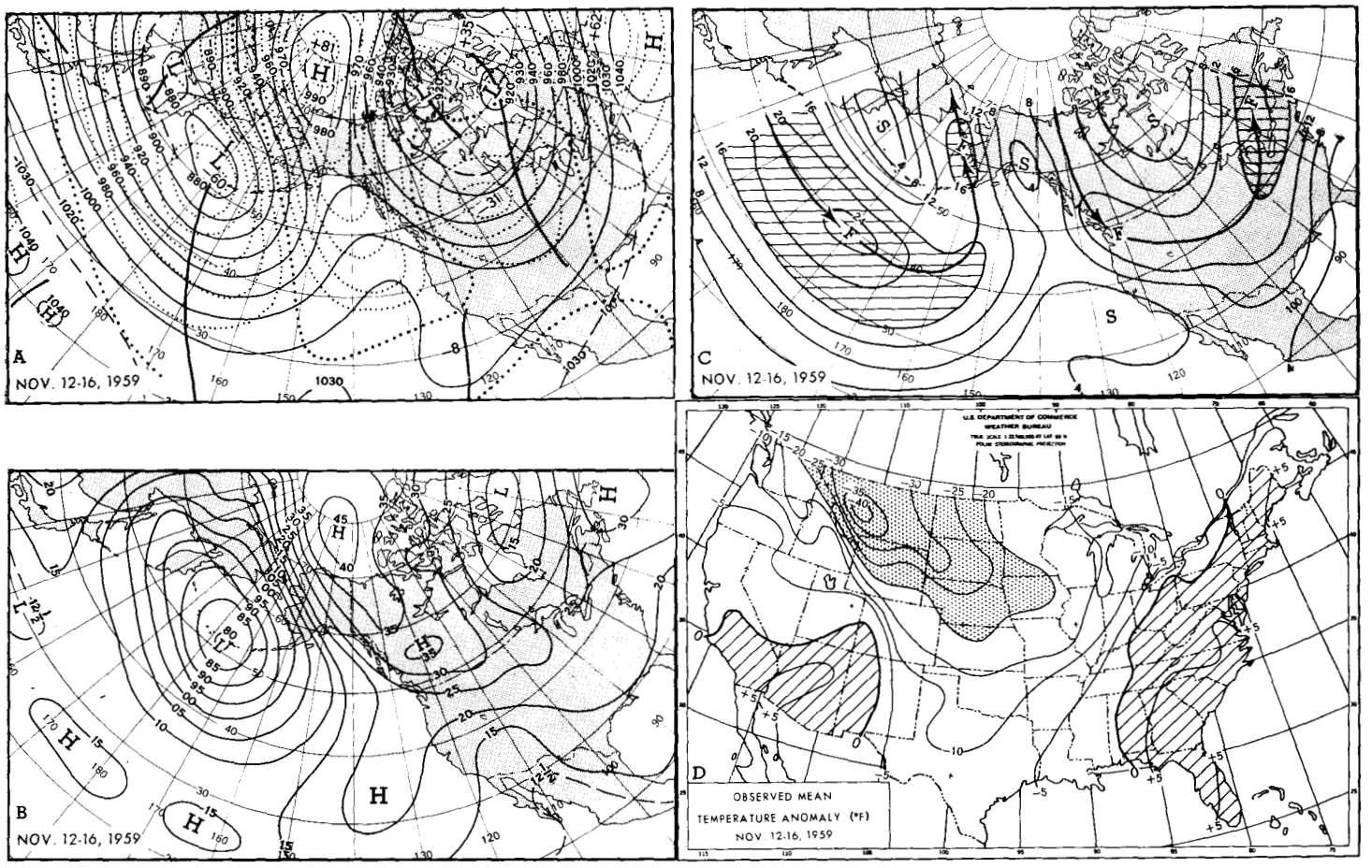

FIGURE 9.—Five-day mean charts for November 12–16, 1959. (A) 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet). (B) Sea level isobars (millibars, hundreds omitted). (C) 700-mb. isotachs (meters per second). Solid arrows indicate primary axes of westerly jet; areas with speeds greater than 16 m.p.s. are hatched. (D) Departure of average surface temperature from normal (°F.); areas with averages more than 20° below normal are stippled. Areas of above normal temperatures are hatched.

tudes in the mid-Pacific. Sea level pressures in this storm were as low as 980 mb. on the 9th and 10th.

The eastern Pacific ridge quickly responded to these developments and built northward, eventually amalgamating over Alaska with the eastward-moving ridge from the Bering Sea. Tracks and intensities of the accompanying 5-day mean 700-mb. height anomaly centers are shown in figure 8. As northward motion continued, an intense block developed over the Arctic Basin, where heights were as much as 810 feet above normal for the period November 12–16, 1959. In figure 9 are shown the corresponding 5-day mean circulation patterns of 700-mb. height, sea level isobars, 700-mb. isotachs with primary jets, and departure of average surface temperature from normal in the United States. The meridional character of the circulation during this period of low zonal index (fig. 7) is strongly evident. Note also the deep Aleutian Low, displaced southwest of its normal position [3], and the strong polar anticyclone centered over the Arctic.

The strong northerly flow thus created in western Canada deployed extremely cold Arctic air masses southward into the northwestern and middle parts of the United States. Moreover, these air masses remained cold since the flow was cyclonic, thus inhibiting subsidence. Temperatures for the period November 12–16, 1959, averaged as much as 40° F. below normal in Montana (fig. 9D). Helena bore the brunt of the bitter weather, reporting a temperature of –39° F. on the 16th, the lowest temperature ever observed there in November. The average temperature on this day was –24° F., 55° F. below the normal. Local blizzard conditions accompanied the frigid weather, with heaviest snowfall in Montana. Most of that State's November precipitation fell as snow, nearly all of it during the period of severe cold. The total snowfall at Helena was 33 inches, breaking an 80-year November record. A snowfall of nearly 22 inches on the 11th and 12th at the same city was the largest for 24 hours for any month.

As the Arctic air swept southward into Texas and eastward to the Great Lakes, it brought new record low temperatures for so early in the season to many stations in the mid-United States, breaking some records for early season cold established in the 1880's. Temperatures dropped as

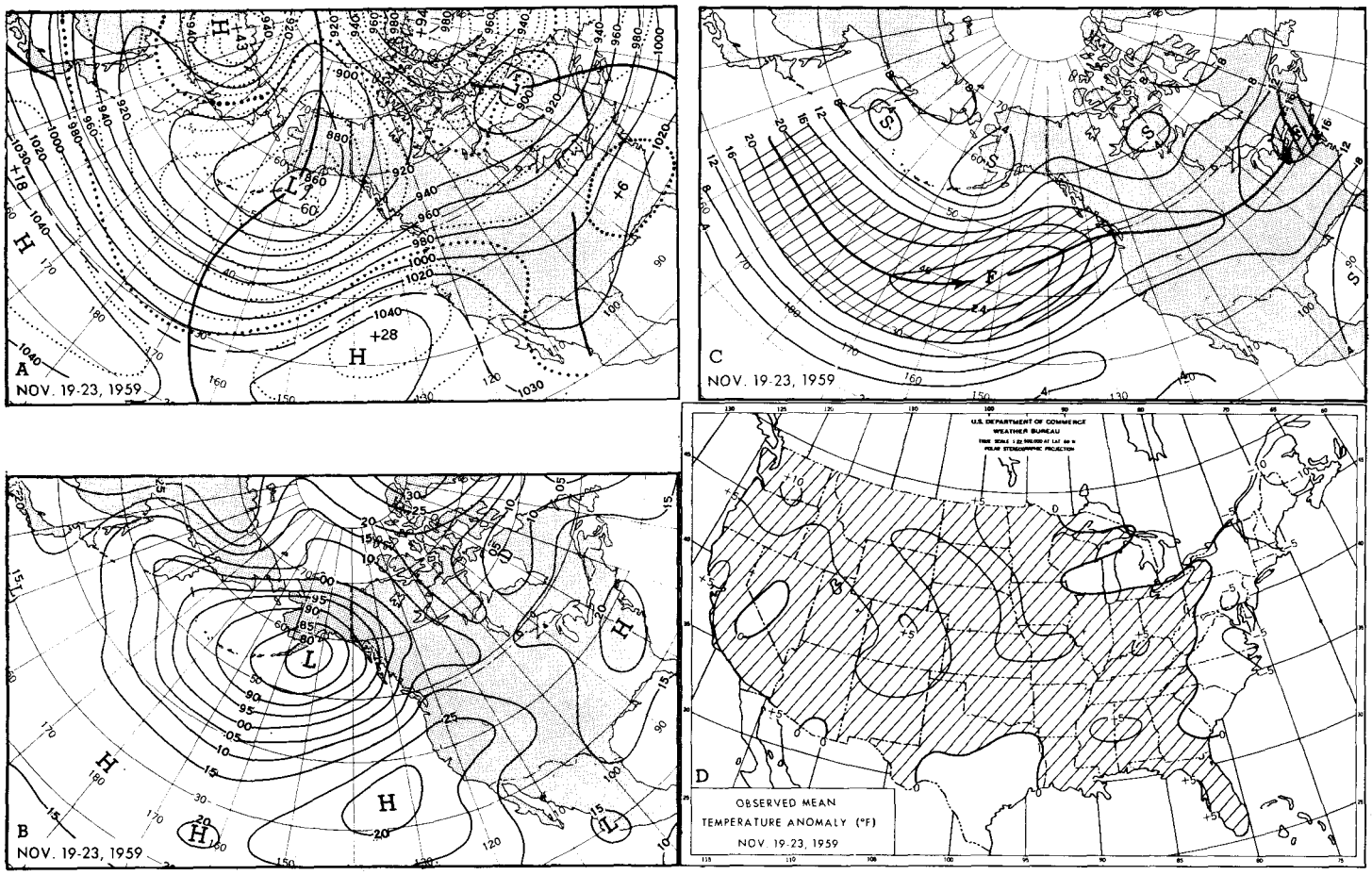

FIGURE 10.—Five-day mean charts for November 19–23, 1959. (A) 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet). (B) Sea level isobars (millibars, hundreds omitted). (C) 700-mb. isotachs (meters per second). Solid arrows indicate primary axes of westerly jet; areas with speeds greater than 16 m.p.s. are hatched. (D) Departure of average surface temperature from normal (°F.), with areas of above normal hatched.

much as 60° F. over the Great Plains States within 24 hours, with below zero readings extending eastward to Wisconsin and southward to northern Kansas. Some of the Arctic air spilled over the mountains into the Pacific Northwest and the northern Great Basin, bringing mostly cold and clear weather to these areas.

It is of interest to point out that the greatest negative temperature anomalies were contained north of the primary jet axis (figs. 9C, 9D). Furthermore, the period of extreme cold from the 12th to 16th occurred after the zonal index had reached its minimum (Nov. 7–11) and during the ensuing period of rapid recovery (fig. 7). This tendency to have the most severe cold just after index minima was noted early in extended forecasting practice.

During the following week (Nov. 19–23, 1959, fig. 10) the rapid increase in westerlies over the Pacific and North America was associated with a marked reversal in circulation and weather over most of the United States. Retrogression and gradual weakening of the polar block allowed the deep Aleutian Low to move northeastward to its more normal position (figs. 10A, 10B). The motion of these two centers of action combined to produce a rapid decrease in amplitude and eastward motion of the eastern Pacific ridge, along with a marked increase in the strength of the westerlies. This increase in westerly momentum spread across North America as the mean 700-mb. jet axis was displaced northward west of the Mississippi Valley (fig. 10C) and effectively contained the cold Canadian air masses.

Much warmer weather accompanied this change in mid-tropospheric circulation, with above normal temperatures observed in the area where one week before they averaged far below normal (figs. 9D, 10D). Figure 11 shows that the greatest increase in average temperature bewteen the two 5-day periods was 49° F. at Helena, Mont.

Strong westerly winds brought rapid warming and very heavy rains over the western slopes of the Cascades and along the coast to central Oregon. A temperature of 69° F. at Yakima, Wash., on the 23d, established a record for so late in the season. As much as 6 inches of rain fell locally in 24 hours, with the amounts at Seattle and Olympia, Wash., setting November records. Serious

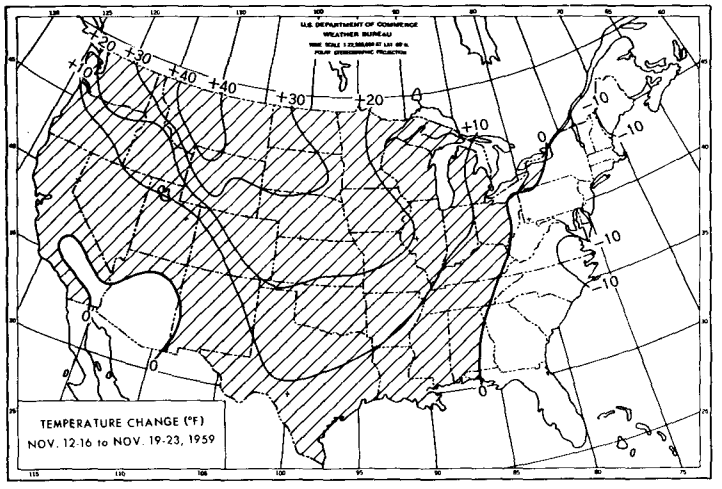

FIGURE 11.—Change in 5-day mean surface temperature anomalies (°F.) from November 12–16 to November 19–23, 1959. Hatched areas represent a change to warmer.

flooding occurred along the Green, Snoqualmie, and Snohomish Rivers in Washington as alltime high flood stages were recorded.

Major reversals in weather and circulation of the type described above are not particularly uncommon. Saylor and Caporaso [5], using daily synoptic charts, found that similar abrupt changes of this type occurred nearly every November, often heralding the onset of winter in the central United States. This year, however, persistent cold was gradually replaced by a warm regime.

6. PACIFIC TYPHOONS

Tropical storm activity during November was confined primarily to the Pacific, where two typhoons were observed. Tracks of these storms, Emma and Freda, superimposed on the mean 700-mb. contours for the month, are shown in figure 12. Both storms recurved in the usual area of recurvature. After recurvature, however, neither assumed the characteristics of a deep extratropical storm, but instead both were swept rapidly eastward as weak disturbances. This lack of development was probably associated in part with the stronger than normal ridge in the western Pacific (fig. 1).

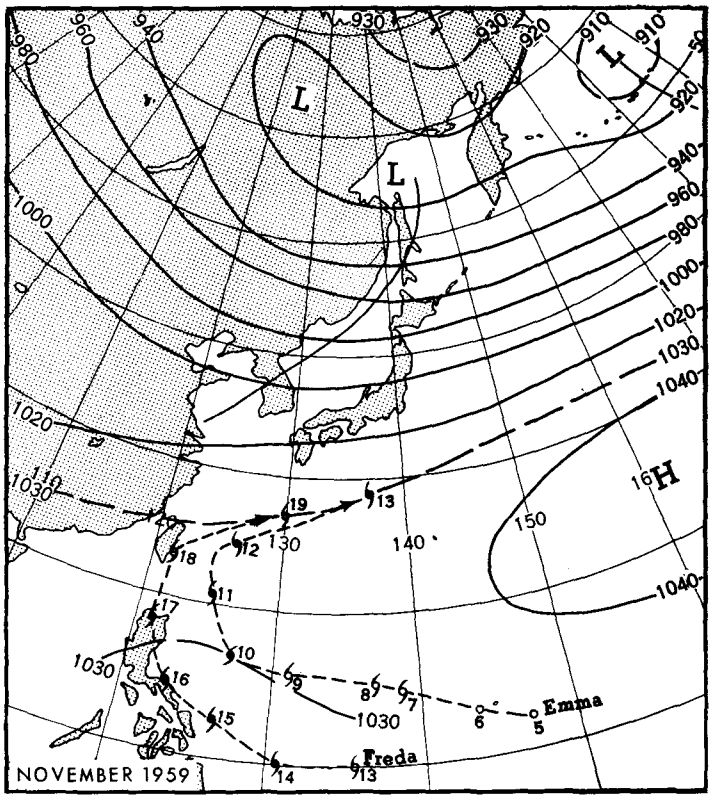

FIGURE 12.—Tracks of Pacific typhoons superimposed upon mean 700-mb. height contours (same as fig. 1) for November 1959.

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